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OPTICAL SENSOR
[OPTISCHER SENSOR]

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Description /1*

The invention relates to an optical sensor with the characteristics named in the preamble of Claim 1, as well as its use.

State of the Art

Different types of sensors for detecting samples and substances are known, e.g. gas sensors for early fire recognition and fire alarms. In the older German patent application 197 41 335.8, optically-operating gas sensors are described that are based on the principle of measurement of an interaction of specific gases with a layer that is permeable to part of the light, whereby a degree of absorption of densely determined wave length is dependent on the gas concentration. The disadvantages of the known optical gas sensors include, among other things, the relatively complicated and voluminous measuring attachment, since in addition to an optical transmitter and an optical receiver, an arrangement of a gas-sensitive layer inside a beam path between these two components is necessary. Measurements, in which concentrations of specific gases at measuring location that are spatially distant from the optical components and e.g. subject to great temperature and/or vibration stress are to be recorded, can only be carried out with difficulty.

Advantages of the Invention

The optical sensor according to the invention with the characteristics named in Claim 1 offers the advantage that, due to the capability of spatially separating at least one optical transmitter

*Numbers in the margin indicate pagination in the foreign text.

and at least one optical receiver, as well as two sensitive layers that interact with a sample, e.g. a gas or gas mixture, that change for the transmission of light of a specific wave length, integrated components that are very compact and cost-effective can be produced. With a coupling of an integrated module, preferably consisting of an optical transmitter and optical receiver with the sensitive layers that can be used at any location, by way of at least one fiber optic cable, the complete spatial separation of these construction units from each other and thus the positioning of the gas-sensitive layers is also possible at those locations, where because of the spatial conditions and/or the thermal and/or mechanical conditions, no sensitive optical and/or electronic components can be used and installed.

Because of the use of a gas-sensitive layer or membrane that is largely permeable to electromagnetic radiation and upon contact with a gas or gas mixture changes its absorption properties and/or its refractive index for electromagnetic radiation as the sensitive element, in the following also called optodes, very compact gas sensors that can be miniaturized can be manufactured in a simple manner. In connection with the present invention, optode is especially understood to mean polymer layers, which because of their embedded indicator substances exhibit a dependency of the light transmission on the concentration of a specific gas in the atmosphere surrounding the optode. Optodes used according to the invention react selectively and reversibly to the concentration of a specific gas. The interaction of

the indicator substance present in the optode leads, e.g. to an at least local maximum of absorption for electromagnetic radiation, e.g. light. The level of the absorption maximum, i.e. the wave length range, typically lies at different wave length values of the electromagnetic radiation for each specific gas and/or gas mixture, whereby additionally the magnitude of the absorption maximum is correlated with the concentration of the interacting gas and/or gas mixture. By measuring the absorption characteristics of the indicator substance to which the gas is exposed and that interacts with it, which is present in the gas-sensitive layer or membrane, very low gas concentrations can be measured and detected with relatively simple optical devices. Preferably the indicator substance that is present in the gas-sensitive layer, preferably embedded in a polymer matrix, only responds to a specific gas so that with different indicator substances, sensors that operate gas-specifically can be produced.

In an advantageous design of the optical sensor, at least one source for electromagnetic radiation, preferably an optical transmitter and at least one detector for electromagnetic radiation, preferably an optical receiver, at least two optodes that are spatially separated are connected between them in the beam path, which change the transmission and/or absorption properties for the electromagnetic radiation depending on the physical and/or chemical interaction with the specific gas. The at least two optodes are coupled to the transmitter and receiver by at least one fiber optic cable. The source for electromagnetic radiation can be, e.g. an LED as

optical transmitter, which radiates light in a selectable wave length range. The use of a laser light source as the source for electromagnetic radiation is also possible, which has the advantage of a very exact coordination capability of the wave length of the radiated electromagnetic waves to the level of an absorption maximum of the optodes. To detect the electromagnetic radiation, a photodiode can thus be considered as an optical receiver with a frequency range tuned to the radiated wave length of the LED or laser light source. A structure such as this can be produced in a simple manner with very cost-effective individual parts. The optodes that are arranged in the beam path between optical transmitter and optical receiver are preferably quantitatively adjusted and/or calibrated with respect to their absorption characteristics with specific wave lengths so that different light wave lengths can detect different gases with differently reacting indicator substances.

In an advantageous design of the invention, the at least two optodes are connected in series by at least one fiber optic cable with at least one optical transmitter and the at least one optical receiver. In this way, two or more optodes, which additionally are advantageously at a distance from each other, can be used at almost any remote locations. The transmission of the electromagnetic radiation, preferably in the light range, which is almost free of loss, within the fiber optic cable allows the spatial separation of optical transmitters and receivers from the optodes. This means it is possible, without problems, to use the optodes at locations, which

because of e.g. their temperature stress are unsuitable for using sensitive optical and electronic components. The optodes can be coupled using series, as well as parallel, connection or even in a combination of series and parallel connection. The design of the connection and/or coupling of the at least one fiber optic cable with the optodes can advantageously be designed so that a shroud that surrounds the core of the fiber optic cable over its entire length is interrupted at individual locations and each of these locations is covered with a gas sensitive layer forming the optodes. These sections at which the shroud is interrupted can either be designed as e.g. oval windows or even as sections in which the core is freed from the shroud over its entire circumference and instead of that is covered with the gas-sensitive layer representing the optode. The core that conducts the light signals almost free of attenuation consists e.g. of quartz glass. /2

In an advantageous design, the refractive index (n_2) for the light of the core of the fiber optic cable is selected in such a way that it lies significantly over the refractive index (n_3) for light of the shroud. In this way, a situation is achieved in which light guided in the core of the fiber optic cable is deflected with total reflection at a core-shroud boundary surface and thus does not leave the core, whereby conduction of light free of loss is also ensured. By suitable selection of a material for the gas-sensitive layer with a refractive index (n_3) for light of the optodes with a value approximately equal to the refractive index (n_2) for light of the

core, in an advantageous manner a situation can be achieved in which light guided in the core can penetrate a core-optode boundary surface almost free of reflection, but is deflected with total reflection at an optode-air boundary surface and penetrates into the core again. Because of an interaction of the optodes with a surrounding gas and/or gas mixture, the transmission behavior for light of the optodes changes. A light beam passing through the optode is thereby attenuated. This attenuation of the light can be recorded and analyzed by means of an evaluation unit connected after the optical receiver. By appropriately selected sensitivity, very precise values can be determined and displayed for different gas concentrations. In an advantageous design of the invention, a fiber optic cable with several optodes at a distance from each other is provided, which each react sensitively to the same gas and/or gas mixture. In this way, with appropriate routing of the fiber optic cable, the gas and/or the gas mixture can be detected at any locations even in very small concentrations in a simple manner.

In another advantageous design of the invention, the at least one fiber optic cable is provided over its length with several optodes at a distance from each other, which are each sensitive to different gases. By suitable modulation of the light emitted by the optical transmitter and appropriate evaluation and signal allocation by means of the evaluation unit connected downstream of the optical receiver, the gas concentration can be determined with high precision at each individual optode. To do this, it is advantageous to analyze the

propagation time of the pulses and in this way assign the different signals precisely to the different optodes, whereby the reflected signals at the optodes acting as interfering points in the fiber optic cable are evaluated. In an advantageous way, the at least one fiber optic cable can be designed so it is ring-shaped, whereby a routing with simple coverage is also made possible within larger areas, as well as unambiguous assignment capability of the signals arriving at the optical receiver to the individual optodes.

In another advantageous design of the invention, it is planned to provide more than one ring-shaped fiber optic cable. For example, two or more fiber optic cables designed with a ring shape can be used for optodes sensitive to each different gas and/or gas mixture. These several fiber optic cables can advantageously be bundled and routed in parallel, which makes possible a reliable detection of different gases and/or gas mixtures at defined locations, even those lying at a great distance. It is also advantageous to provide a common optical transmitter for the at least two fiber optic cables used, which among other things reduces the construction effort. However, advantageously each of the several fiber optic cables is coupled with a separate optical receiver in order to permit reliable signal evaluation. In order to obtain construction units that are compact and have as much operational security as possible, it can be advantageous to connect optical transmitter and receiver in a monolithic assembly, e.g. by casting with plastic, with the front sides of the fiber optic cables. Alternatively, optical transmitter and receiver can also be combined

spatially in a common module or integrated in a common component, which has considerable advantages with respect to easier installation.

The optical sensor according to the invention can also be used advantageously for monitoring air quality in rooms, especially for control of ventilating flaps in air conditioning systems. Optical sensors according to the invention can also be used for ventilation and air conditioning control in indoor rooms and/or in tunnels. Naturally this type of optical sensor is also suitable for smoke and/or fire alarms, whereby because of a determination of gases from fires by individual optical sensors or a combination of several sensors, the detection and alarm time is greatly reduced in comparison to known devices and the security against false alarms can be significantly increased. In the manner described above, a very simply structured, maintenance-free and reliable optical fire alarm can be produced by routing fiber optic cables provided with corresponding optodes over large areas. Because of the extremely low power consumption of the semiconductor components preferably used as optical transmitter and receiver, e.g. designed as LEDs, fire alarms that are independent of the power network can be produced using battery backup. Another advantageous application possibility is a detection of hydrocarbons.

Other advantageous designs of the invention can be seen from the other characteristics named in the subclaims.

Drawings

The invention will be described in more detail in the following

with an embodiment example using the associated drawings. In the drawings:

Fig. 1 shows a schematic representation of a first variation of an individual optical sensor;

Fig. 2 shows a schematic representation of a variation of an optical sensor with several fiber optic cables;

Fig. 3 shows a schematic representation of another variation of an optical sensor;

Fig. 4 shows a schematic representation of a fiber optic cable provided with optodes and

Fig. 5 shows a representation of the principles of reflection processes in fiber optic cable and at the optode. /3

Description of the Embodiment Examples

Fig. 1 shows a measuring setup for an optical sensor, consisting of a source for electromagnetic radiation as optical transmitter **2**, in this case e.g. an LED, a detector for electromagnetic radiation as optical receiver **4**, e.g. a photodiode that is coupled by way of a fiber optic cable **10** with several sensitive elements at a distance from each other, called optodes **12** in the following. However, for example, a laser light source can be used equally well as a source for electromagnetic radiation.

In many applications, it is desirable to separate the gas-sensitive layers and/or the optodes **12** spatially from the optical transmitter **2** and optical receiver **4**, e.g. in fire alarms or sensors that have to interact with very hot gases. The two semiconductor

components can, for example, be mounted as so-called SMD (surface mounted device) components on a common circuit board in a housing that is not shown here, while in contrast the optodes **12** are preferably mounted at locations that are more easily accessible to the gas to be detected, i.e. outside the housing. For optical coupling of the optodes **12** with the optical transmitters **2** and the optical receiver **4**, according to the invention the use of at least one fiber optic cable **10** is provided. The light radiated from the optical transmitter **2** is thereby coupled in the fiber optic cable **10**, preferably on a flat face side **36**, which on its other end turned toward the optical receiver **4**, has a face side **37** that is also flat, which is arranged perpendicular to the longitudinal direction of the fiber optic cable **10**. In this way, a spatial separation of electronics and optodes **12** is possible.

Optical transmitters **2** and receivers **4** can be used that operate with infrared or ultraviolet light or with light in the visible wave length range, preferably in each case in a narrow wave length range. The coordination between the wave length of the light transmitted by optical transmitter **2** and the wave length absorbed in the gas sensitive layers and/or optodes **12** described in the following is decisive for the function of the measuring setup.

The gas sensitive layers and/or optodes **12** each consist of a carrier material that is largely inert, preferably a polymer material and an indicator substance embedded on it or applied to it. Upon contact with specific samples, e.g. a specific gas and/or gas mixture,

the indicator substance exhibits an interaction in the form of transmission change for electromagnetic radiation of a specific wave length. With a specific gas concentration, there is a fixed relationship to the degree of absorption of transmitted light. The effectiveness of the gas sensitive layers have been proven to date for a number of different gases and gas mixtures, whereby the smallest gas concentrations that could be detected to date lie in the range of a few ppb.

Each of the optodes **12** mounted on the fiber optic cable **10** in the embodiment example shown contains an indicator substance sensitive to a specific gas and/or gas mixture and will calibrated by means of measurements prior to the installation. As soon as the gas to be detected enters the area between optical transmitter **2** and optical receiver **4**, e.g. it reaches at least one of the optodes **12** and interacts with its indicator substances, the indicator substances contained in the optodes **12** change their absorption for specific wave length ranges of the electromagnetic radiation interacting with it. Since this wave length corresponds to a local absorption maximum of the indicator substance, the optical receiver **4** registers a modified amplitude of the light signal received. The magnitude of the absorption maximum is proportional to the concentration of the gas in the previously known optodes **12**. The light signal received can be recorded by means of an evaluation unit that is not shown and sent, e.g. to a sensor.

In the embodiment example shown, the optodes **12** connected in

series are each calibrated to the same substance, whereby with adequately long fiber optic cable **10** and the optodes **12** mounted on it and at a distance from each other for measuring, a detection of a specific gas and/or gas mixture is possible over great distances and/or within a wide area. For example, with an optical sensor of this type, with only very few components and with only one line, namely the fiber optic cable **10**, a highly sensitive fire alarm can be produced with appropriately selected sensitivity of the optodes **12**. By supplying suitably modulated light signals through the optical transmitter **2** (in this case a laser) and a suitable evaluation with respect to the propagation times, it is also possible to detect the interaction of each individual optode **12** with the gas and/or gas mixture. In this way, it is possible to record and display the location, for example of a fire, with high precision.

Fig. 2 shows, in a schematic representation, a variation of an optical sensor, in which several fiber optic cables **10** are each provided with several optodes **12, 13, 14**. The same parts as in Fig. 1 are provided with the same reference numbers and will not be explained again. In the embodiment example shown, three fiber optic cables **10** designed with ring shapes are supplied to a common optical transmitter **2**. However it is also possible to provide a separate optical transmitter **2** for each individual fiber optic cable, whereby these several optical transmitters **2** each can transmit electromagnetic radiation either in the same or in different wave length ranges. It is

also possible to provide a number of fiber optic cables **10** instead of only three.

For each of the three fiber optic cables **10**, a separate optical receiver **4, 6** and **8** is provided so that an analysis of the optodes **12, 13, 14** interacting with different gases and/or gas mixtures is possible. The optodes **12, 13, 14** connected with the fiber optic cables **10** are advantageously calibrated and coordinated in such a way that the optodes **12** of the first fiber optic cable **10** are sensitive to a specific gas and/or gas mixture, the optodes **13** of the second fiber optic cable **10** are sensitive to another gas and/or gas mixture and the optodes **14** of the third fiber optic cable **10**, in turn are sensitive to a gas and/or gas mixture different from that. An arrangement of this type can be expanded as desired with additional fiber optic cables with individually calibrated optodes mounted on them.

In the embodiment example shown, optodes **12, 13, 14** that are the same, i.e. are sensitive to the same substance, are provided for each fiber optic cable **10**. In the way described in Fig. 1, these can be at a lesser or greater distance from each other so that if necessary, a detection of substances over long distances and within wide areas is /4 possible. For example, the optodes **12, 13, 14** can be calibrated, for example, in such a way that they are sensitive to different combustion gases, whereby a more reliable fire detection and alarm is made possible than with the use of only optodes **12** sensitive to one combustion gas. In order to the detect all desired substances in the

desired areas, it is advantageous to route three fiber optic cables **10** in parallel. The use of an individual optical receiver **2, 4** and **6** for each fiber optic cable **10** to be used makes evaluation easier with respect to different gases and/or gas mixtures to be detected. If in addition, as already described in Fig. 1, the exact locations of the interactions of an optode **12, 13, 14** with a gas and/or gas mixture are to be detected and analyzed, the signal processing of the evaluation unit in one of the three optical receivers **4, 6** and **8** that is connected downstream, is less complicated if three optical receivers **4, 6** and **8** are used, than the use of only one.

Fig. 3 shows, in a schematic representation, another variation of an optical sensor. The same parts as in the previous figures are provided with the same reference numbers and not explained again. In this case, only one fiber optic cable **10** is provided with several optodes **12, 13** and **14** that are each sensitive to different substances and/or gases and/or gas mixtures. The optical transmitter **2** at one end of the fiber optic cable **10** sends electromagnetic radiation in the wave length range, in which the optodes **12, 13** and **14** exhibit a change in transmission with interaction with a specific gas and/or gas mixtures. The optical receiver **4** at the other end of the fiber optic cable forwards the signals received to an evaluation unit not shown here, which is able to compare the signal received, with respect to the amplitudes with the relevant frequencies, to the signal transmitted by the optical transmitter **2** and from that, make

statements about the detected substances and their precise location. However in order to make the latter possible, it is necessary to modulate the signal transmitted by optical transmitter **2** in a suitable way and to evaluate the reflected signal received at an optical receiver at the fiber optic input with respect to the pulse responses.

This means it is possible, for example, to position several groups of different optodes **12, 13** and **14**, which are placed close to each other, at a distance from each other sequentially at the fiber optic cable, so that in this way three different substances, e.g. three different gases and/or gas mixtures can be detected at a number of different locations, whereby the displays can each be assigned exactly to the different defined locations. If a fire alarm, for example, will be produced with the use of the optical sensor, the locations of a developing fire can be determined precisely even over large areas because of the combustion gases that are released there and registered by the optodes **12, 13** and **14**.

Fig. 4 shows a cutout of a structure of a fiber optic cable **10** arranged in the beam path between an optical transmitter **2** and optical receiver **4** with optodes **12, 13, 14** mounted on it. The same parts as in the previous figures are provided with the same reference numbers and will not be explained again. A core **20** of the fiber optic cable **10** can be recognized, which is shrouded by a shroud **22** over its entire length. The refractive index for light of the core **20** (n_2) typically has a significantly higher value than that of the shroud **22** (n_1). If quartz glass, for example, is used as the material for the fiber optic

cable, it has a refractive index of $n_2 = 1.46$. For air the value of the refractive index is $n = 1$. The value of the refractive index of the shroud **22** thus advantageously lies between these two values, e.g. $n_1 = 1.2$. A situation is hereby achieved in which the light guided in the core **20** is reflected almost free of attenuation and almost completely at a core-shroud boundary surface **21**. In the embodiment example shown, a section **24** and/or a window **25** is provided in which the core **20** is exposed, i.e. freed of the surrounding shroud **22** and covered and/or shrouded with a gas sensitive layer and/or an optode **12, 13, 14**. Advantageously, the material of the optode **12, 13, 14** has a value for the refractive index (n_3) that corresponds approximately to that of the core **20**. With the use of quartz glass as the material for the core **20** of the fiber optic cable **10**, advantageous values thus result for the refractive index $n_2 = n_3 = 1.46$. In this way, a situation is achieved in which a light beam can pass through a core-optode boundary surface **27**, but will be completely reflected at an optode-air boundary surface **23** because of the clearly different refractive index.

Fig. 5 shows the reflection processes in the fiber optic cable **10** in a detailed schematic view. The same parts as in the previous figures are provided with the same reference numbers and will not be explained again. The core **20** can be seen with surrounding shroud **22**, which is interrupted at an example section **24**. An optode **12, 13, 14** is located there. A light beam **30** that has been drawn as an example is

reflected at the core-shroud boundary surface **21** because of the different refractive indices and thus remains in the core **20**. Another light beam **32** can penetrate the boundary surface **27** unimpeded, i.e. almost free of loss, because of the refractive indices that are approximately equal and then will be reflected at the optode-air boundary surface **23**, which lies at the value of the refractive index in air (n = 1) that is clearly lower than the value for the refractive index of the optode (n_3). The light beam **32** thus also remains in the core **20**, but is significantly attenuated when passing through the optode **12, 13, 14**, depending on the interaction with a specific substance. With a suitable triggering of the optical transmitter **2** with a modulated signal and of the optical receiver **4**, as well as the evaluation unit connected downstream, this attenuation can be evaluated as a detection of a substance.

Patent Claims

1. Optical sensor for determining at least one physical and/or chemical parameter of a sample with at least one optical sensor and at least one optical receiver and sensitive element in the beam path arranged between the at least one optical transmitter and the at least one optical receiver that can be exposed to the sample, which upon parameter change of the sample changes its absorption and/or its refractive index for electromagnetic radiation of a specific wave length, especially a gas sensitive element and possibly with an evaluation unit connected downstream of the at least one optical receiver, **characterized in that** the at least one optical transmitter

(2) and the at least one optical receiver (4,6,8) is coupled by way of at least one fiber optic cable (10) with at least two sensitive elements at a distance from each other.

2. Optical sensor according to Claim 1, characterized in that the elements sensitive to electromagnetic radiation are mainly /5 translucent optodes (12, 13, 14), which upon contact with the sample change their absorption characteristics and/or their refractive index for electromagnetic radiation.

3. Optical sensor according to Claim 2, characterized in that the sample is a gas and/or a gas mixture.

4. Optical sensor according to Claim 3, characterized in that the optodes (12, 13, 14) each have an indicator substance, which with at least indirect contact with at least one specific gas and/or specific gas mixture interacts chemically or physically reversibly with the gas or gas mixture.

5. Optical sensor according to Claim 4, characterized in that the interaction leads to an occurrence of at least one local absorption maximum for electromagnetic radiation.

6. Optical sensor according to Claim 5, characterized in that the level of the absorption maximum for each specific gas and/or gas mixture lies at different wave length values of the electromagnetic radiation.

7. Optical sensor according to one of the preceding claims, characterized in that the magnitude of the absorption maximum is correlated with the concentration of the interacting gas and/or gas

mixture.

8. Optical sensor according to one of Claims 2 to 7, characterized in that the at least two optodes (12, 13, 14) are connected in series by way of at least one fiber optic cable (10) to at least one optical transmitter (2) and the at least one optical receiver (4, 6, 8).

9. Optical sensor according to one of Claims 2 to 7, characterized in that the at least two optodes (12, 13, 14) that are connected in parallel by way of at least one fiber optic cable (10) with at least one optical transmitter (2) and the at least one optical receiver (4, 6, 8).

10. Optical sensor according to one of the preceding claims, characterized in that the fiber optic cable (10) that couples the at least one optical transmitter (2) with the at least one optical receiver (4, 6, 8) has a core (20) that conducts light signals approximately free of attenuation and a shroud (22) that surrounds the core (20) over the entire length of the fiber optic cable (10), whereby the shroud (22) has a window (25) at least one section (24) in which the core (20) is completely covered by an optode (12, 13, 14).

11. Optical sensor according to one of Claims 2 to 9, characterized in that the fiber optic cable (10) coupling the at least one optical transmitter (2) with the at least one optical receiver (4, 6, 8) has a core (20) that conducts light signals almost free of attenuation and a shroud (22) surrounding the core (20) over the entire length of the fiber optic cable (10), whereby the shroud (22)

is interrupted in at least one section (24) and the core (20) is completely surrounded by an optode (12, 13, 14) at this section (24).

12. Optical sensor according to one of Claims 10 to 11, characterized in that the refractive index (n_2, n_3) for the light of the core (20) and/or of the optode (12, 13, 14) has significantly higher values than the refractive index (n_1) for the light of the shroud (22).

13. Optical sensor according to Claim 11, characterized in that the refractive index (n_2) of the core (20) and the refractive index (n_3) of the optode (12, 13, 14) have approximately equal values.

14. Optical sensor according to Claim 13, characterized in that over its length, the fiber optic cable (10) has several sections (24) at a distance from each other, with optodes (12, 13, 14) that are each sensitive to the same gases and/or gas mixtures.

15. Optical sensor according to Claim 13, characterized in that the fiber optic cable (10) has several sections (24) at a distance from each other, with optodes (12, 13, 14) that are each sensitive to different gases and/or gas mixtures.

16. Optical sensor according to one of the preceding claims, characterized in that the optical transmitter (2) has a source for electromagnetic radiation, especially an LED that is selected in such a way that its emission spectrum matches the gas-sensitive absorption of the optode.

17. Optical sensor according to one of Claims 1 to 15, characterized in that the optical transmitter (2) is a source for

electromagnetic radiation, especially of a laser light source, of a discrete wave length.

18. Optical sensor according to one of the preceding claims, characterized in that the optical receiver (4, 6, 8) is a photodiode.

19. Optical sensor according to one of Claims 14 to 18, characterized in that the at least one fiber optic cable (10) is designed with a ring shape.

20. Optical sensor according to Claim 19, characterized in that at least two fiber optic cables (10) designed with ring shape are each used for optodes (12, 13, 14) sensitive to different gases and/or gas mixture.

21. Optical sensor according to Claim 20, characterized in that the at least two fiber optic cables (10) that are used are provided with a common optical transmitter (2).

22. Optical sensor according to Claim 21, characterized in that each of the at least two fiber optic cables (10) used is each provided with one optical receiver (4, 6, 8).

23. Optical sensor according to Claim 22, characterized in that the at least two fiber optic cables (10) that are used are cast in a common housing with the at least one optical transmitter (2) and the at least one optical receiver (4, 6, 8).

24. Optical sensor according to Claim 23, characterized in that the at least two fiber optic cables (10) used are cast with plastic with the at least one optical transmitter (2) and the at least one optical receiver (4, 6, 8).

25. Optical sensor according to Claim 24, characterized in that the at least one optical transmitter (2) and the at least one optical receiver (4, 6, 8) are combined spatially and/or in construction.

26. Optical sensor according to Claim 25, characterized in that the at least one optical transmitter (2) and the at least one optical receiver (4, 6, 8) are integrated in a common component.

27. Optical sensor according to one of the preceding claims, characterized in that the optodes (12, 13, 14) preferably interact with gaseous combustion productions.

28. Optical sensor according to one of the preceding claims, /6 characterized in that the signals received by at least two different optodes (12, 13, 14) can be recorded with respect to their specific propagation times in the evaluation unit.

29. Optical sensor according to Claim 28, characterized in that different propagation times of the signals supplied by the different optodes (12, 13, 14) can be evaluated to obtain location information.

30. Optical sensor according to Claim 29, characterized in that several ring-shaped fiber optic cables (10) detect fires in wide areas and that the signals supplied can be evaluated in the evaluation unit with respect to the location of the fire.

31. Use of at least one of the optical sensors according to Claims 1 to 30 in fire alarms.

32. Use of at least one of the optical sensors according to Claims 1 to 29 for determining and monitoring air quality in rooms.

33. Use according to Claim 32, characterized in that equipment

for ventilation and air conditioning controls in indoor rooms can be controlled using the measurements obtained.

34. Use according to Claim 32, characterized in that the concentration of CO and/or CO_2 is recorded.

35. Use according to Claim 32, characterized in that ventilation systems in tunnels are regulated with the measurements obtained.

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2 Page(s) of drawings follow

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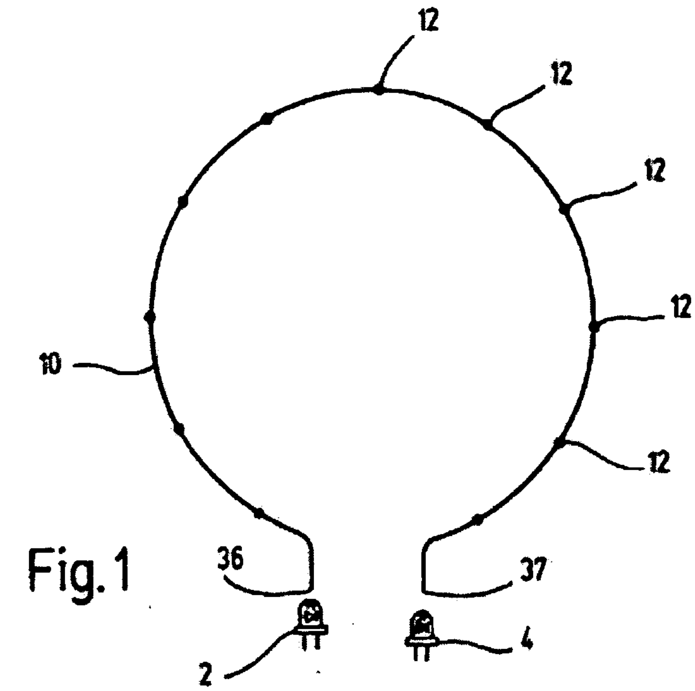
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Fig.1

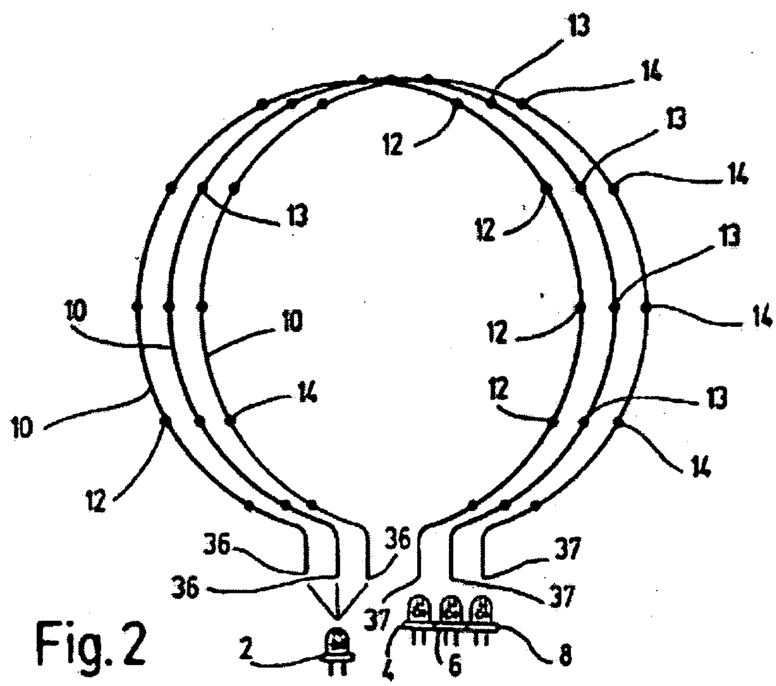
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Fig.2

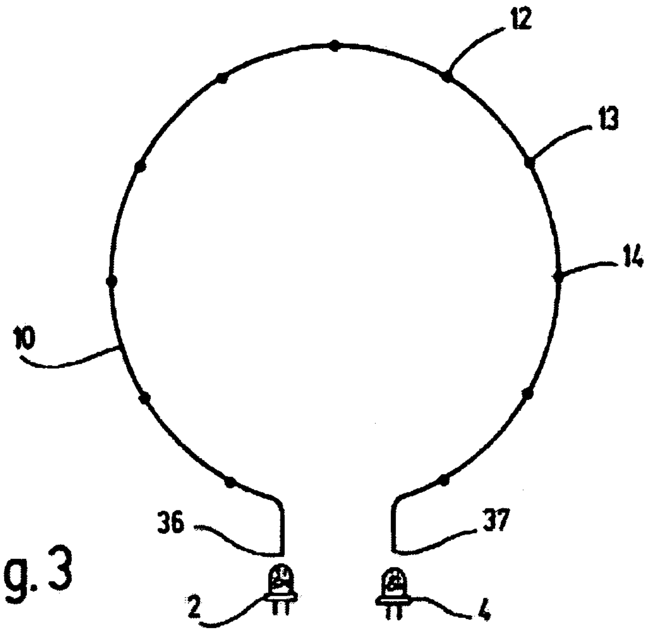

Fig. 3

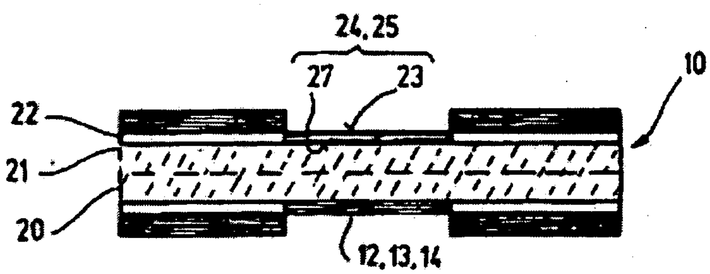

Fig. 4

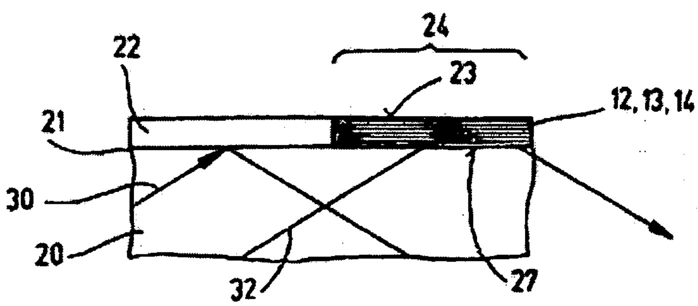

Fig. 5